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THE VARIATION OF IONOSPHERIC PROFILE WITH SEASON AND SOLAR CYCLE†

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Measurements of daytime ionospheric electron content made from September 1958–September 1960 using the satellite Doppler effect are converted to values of equivalent slab thickness, τ, at maximum density, N_{max}. The behavior of the noon value of τ with season and with solar cycle is discussed briefly in relation to satellite drag measurements of atmospheric density at F region heights.

MEASUREMENT of propagation effects produced in satellite radio signals as they pass through the ionosphere can lead to the determination of ionospheric electron content below the height of the satellite.[1] For satellite heights in excess of about 700 km, this content is essentially that of the F region of the ionosphere. With the usual satellite orbits evaluation of ionospheric profile is not possible directly.

Recordings of the dispersive Doppler effect in the harmonic radiations from 1958 Delta 2 (Sputnik III) have been made during daylight throughout its lifetime, and further observations have been made on the satellite 1960 Eta (Transit 2A) during the latter part of 1960. These data have been reduced to values of electron content to the satellite height for heights in excess of 700 km.

A profile-related parameter τ is defined as the ratio of electron content, measured by satellite observation, to the maximum electron density of the F layer for the same time, measured by sounding methods. τ is then the equivalent slab thickness of the total ionosphere, which is essentially the equivalent slab thickness of the F layer. Plots of τ vs. time of day are shown in Fig. 1 for six series of daylight passes of Sputnik III. Although the scatter is large, some of these plots show a diurnal increase in τ.

Linear regression methods were used to fit best straight lines to these points and the results are shown in Fig. 2. The slope of τ in km/hr is plotted with

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standard deviation limits shown as vertical lines and the number of passes comprising a series indicated in parentheses. The slope is generally positive and of the order 7 km/hr with no well defined seasonal dependence.

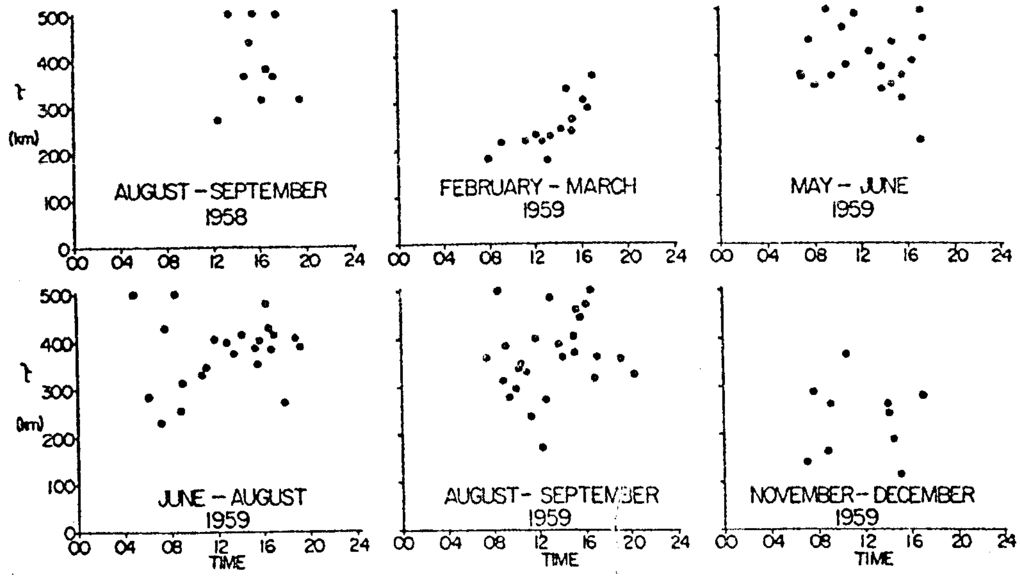

Fig. 1. Diurnal variation of equivalent slab thickness.

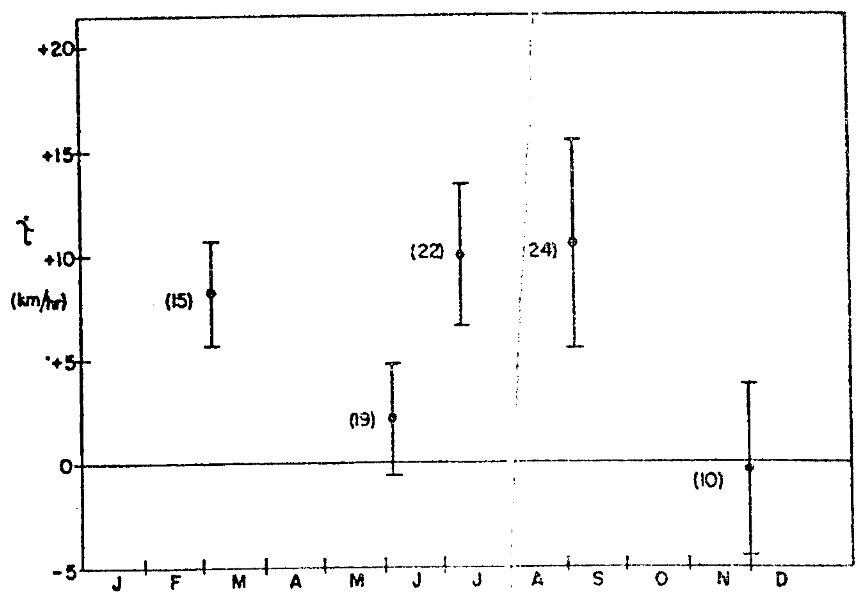

Fig. 2. Variation of τ̇ during 1959.

The normalized noon values of τ are plotted against season in Fig. 3. A pronounced seasonal variation is apparent which can be fitted closely by a sinusoidal function of mean value 290 km at the equinoxes and of amplitude 100 km, which maximizes near the summer solstice.

The value of τ for September 1958 however lies appreciably above the curve. This is investigated further by comparison of the data taken during the autumnal equinox periods of the years 1958 and 1959 (Sputnik III), and 1960 (Transit 2A). The values of τ are shown in Fig. 4, together with the

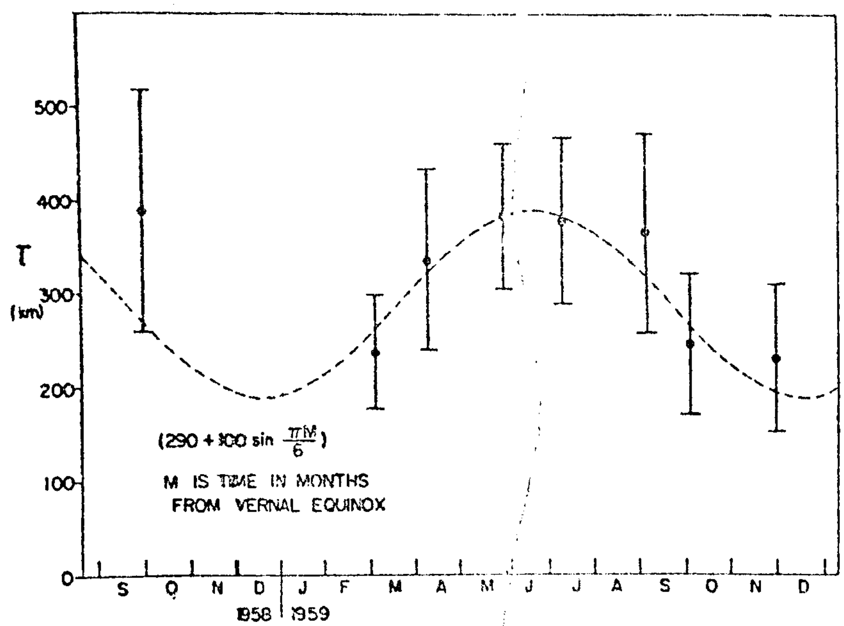

Fig. 3. Seasonal variation of τ.

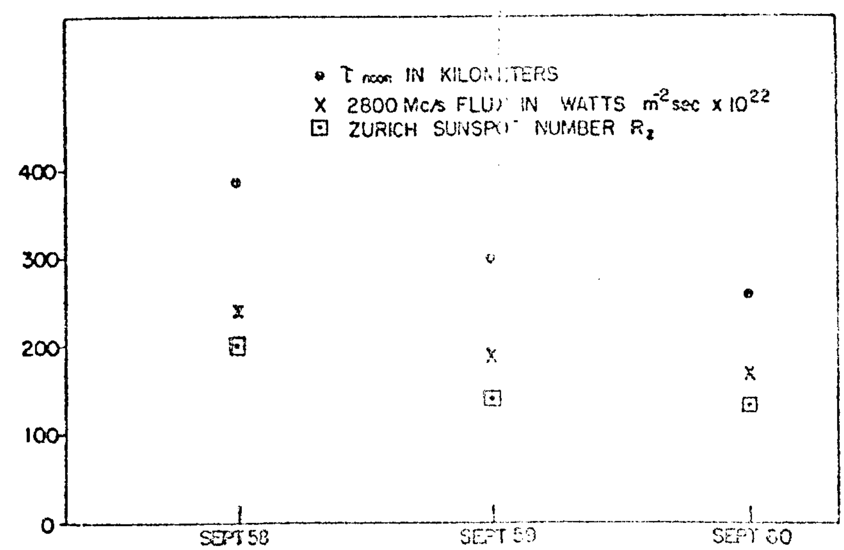

Fig. 4. Variation of τ with solar cycle.

corresponding values for these months of the Zürich Sunspot Number R_z, and of the 2800 Mc/s solar flux. It can be seen that all three sets of points show a uniform decrease through the period. We may then infer that the high value of τ in September 1958 was associated with the high solar activity at that time. It is not possible at this time to determine whether this effect of solar activity appears in the mean (equinoctial) value of τ only or whether it also affects the amplitude of the seasonal oscillation of τ.

Independent measurements of atmospheric density at F layer heights have been made using satellite drag effects[2] and these show a decrease in density with falling sunspot number over a similar period, due presumably to a decrease in ionospheric heating at lower altitudes. It seems likely that the variation we have seen in τ through a small part of the sunspot cycle is directly related to this atmospheric behavior.

A similar interpretation of the seasonal dependence of τ receives little support from the satellite drag experiments which have shown relatively little seasonal effect in atmospheric densities at F layer heights.[3] However it must also be recognized that much of this data is derived from satellites with low orbital inclinations, whose results do not therefore extend far into middle latitudes.

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